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Working conditions, psychological/physical symptoms and occupational accidents. Bayesian network models

Susana García-Herrero [a,*], M.A. Mariscal [a,1], Javier García-Rodríguez [b], Dale O. Ritzel [c,2]

[a] Escuela Politécnica Superior, Universidad de Burgos, Avda. Cantabria, s/n., 09006 Burgos, Spain
[b] CSIC – Consejo Superior de Investigaciones Científicas, Spanish National Research Council, Spain
[c] Safety Center, Southern Illinois University, Carbondale, IL 62901-6731, USA

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ABSTRACT

Each day thousands of workers suffer occupational accidents of varying degrees of severity. Accidents at work render workers incapable of carrying out their day to day activities, either temporarily or permanently, and they also have detrimental effects on family life, the company, and the general public. In order to reduce the occupational accident rate, it is necessary to determine the causes of those accidents. Although there are many different types of accidents, they generally stem from poor working conditions. The purpose of this study was to analyze the influence of working conditions on occupational accidents from data gathered in the VI National Survey of Working Conditions (VI NSWCs) in 2007. This survey utilized a random sample of the active population of Spain. The sample comprised 11,054 people (5917 males and 5137 females). In order to carry out the study, a probabilistic model was built using Bayesian networks. The model included the following variables: hygiene conditions, ergonomic conditions, job demands, physical symptoms, psychological symptoms, and occupational accidents. The study demonstrated that there were strong relationships between hygiene conditions and occupational accidents; it has been shown that poor hygienic conditions duplicate the probability of accident. Physical symptoms increased almost 50% due to poor ergonomic conditions. And finally, high job demands almost duplicated the psychological symptoms. The investigation also showed a high degree of interdependence between physical and psychological symptomatologies and the relationship between these and occupational accidents.

1. Introduction

Work conditions and organization are elements that contribute to work accidents. So work safety requires that safe working conditions should not create significant risk of people being rendered unfit to perform their work.

Health was defined by the World Health Organization as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (WHO, 1998). This definition has formed part of the Constitution of the WHO since it was established in 1948. The constitution also recognizes that health is one of the fundamental rights of human beings, and that the attainment of the highest standard of wellbeing is dependent upon the co-operation of individuals and nations and upon the provision of health and social measures.

Health and safety at work is therefore aimed at creating conditions, capabilities, and habits that enable the worker and his or her organization to carry out their work efficiently and in a way that avoids events which could cause them harm.

Occupational accidents cause considerable physical, psychological, and social harm to victims. In addition to the physical and psychological harm, occupational accidents have detrimental effects on the worker's social life and, in turn, can lead to a worsening of the finances of the worker, of his or her company, and of society as a whole. Preventing or reducing the number of accidents and minimizing their consequences are among the main objectives of health and safety in companies.

Theories have been put forward attempting to account for occupational accidents and these have emphasized human error, the worker being distracted, and so on. Nevertheless, accidents happen because there is a risk, and that risk stems from a set of working conditions which influence the behavior of the worker. With appropriate control of those working conditions and, therefore, of the associated risk, it may be possible to prevent accidents, regardless of the individual factors of each case.

* Corresponding author. Tel.: +34 947259084; fax: +34 947258910.
E-mail addresses: susanagh@ubu.es (S. García-Herrero), mariscal@ubu.es (M.A. Mariscal), javier.garcia@orgc.csic.es (J. García-Rodríguez), dritzel@siu.edu (D.O. Ritzel).
URLs: http://www.ubu.es/es (S. García-Herrero), http://www.ubu.es/es (M.A. Mariscal), http://www.csic.es (J. García-Rodríguez).
[1] Tel.: +34 947258933; fax: +34 947258910.
[2] Tel.: +1 618 453 2080; fax: +1 618 453 2879.

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Studies into health and safety at work, aimed at preventing injury, have traditionally concentrated on the physical aspects, dealing with ergonomic factors and musculoskeletal disorders (De Jong et al., 2003; Ghahramani, 2000; Ghosh et al., 2010; Hess et al., 2004) or hygiene conditions such as temperature and noise (Anttonen et al., 2009; Ashraf et al., 2005; Morabito et al., 2006).

Actually, a growing amount of research has, however, been focusing on establishing links between the psychological factors and accident rate (Bardera Mora et al., 2002; Dwyer and Raftery, 1991; Gillen et al., 2002; Glasscock et al., 2006; Hilton and Whiteford, 2010; Sobeih et al., 2009). These studies analyzed the influence of the stress in the health and safety of workers. Results indicated that stressors and stress symptoms were predictors of occupational accidents.

Stress has now become a relevant and socially recognized phenomenon, frequently linked to work and labor activities. There is no globally accepted definition of stress and, due to its wide diffusion, the term is used to refer to a wide variety of states (Belloch et al., 1995; Kasl, 1978; Lazarus and Folkman, 1984; McGrath et al., 1970; Selye and Ogilvie, 1956). The International Labour Organization (ILO, 2012) refers to occupational stress as the harmful physical and emotional response that occurs when the requirements of the job do not match the capabilities, resources, or needs of the worker (Gabriel and Liimatainen, 2000).

Several studies have focused on the influence of work-related factors on stress, including ergonomic conditions (Hoyos, 1995), work shifts (Barton, 1994; Cervinka, 1993), excessive workload (Barnett and Brennan, 1995; Perrewe and Ganster, 1989), job demands and job control (Karasek et al., 1981, 1988), monotonous and repetitive tasks (Melamed et al., 1995), work flexibility (Russell et al., 2009), conflicts and ambiguous workload (Bedeian and Armenakis, 1981; Cosway et al., 2000), and a lack of co-worker support (Brage et al., 1998; Karasek and Theorell, 1994; Mirowsky and Ross, 2003; Thompson et al., 2005).

Turning to the more physical aspects, another health issue which has been highlighted in research over the last few decades is the problem of musculoskeletal disorders or physical symptoms. These include disorders of the muscles, tendons, nerves, or joints which can occur in any part of the body, although they most commonly affect the neck, back and upper extremities. While they may be due to factors outside the workplace and may even have personal causes, working conditions are linked directly to musculoskeletal disorders. The prevention of musculoskeletal disorders is directly linked to the correct design of the job (for example, allocated space or provision of adequate lighting), and to the physical demands (for example, moving heavy loads and doing repetitive tasks).

In addition to being a problem for the health of workers, these disorders constitute a significant financial burden on society. Most of the financial losses associated with occupational injuries and illnesses involve musculoskeletal disorders (Takala, 2002), and these disorders are the main cause of the loss time injuries in developed countries (Brage et al., 1998; Woolf and Pfleger, 2003).

Although it is undeniable that these physical symptoms stem from the job design, there is also literature (Feuerstein et al., 2004; Van den Heuvel et al., 2005) which claims that these symptoms are caused or aggravated on many occasions by psychological factors.

Concluding, emphasis is currently being placed on improving working conditions in order to reduce occupational accident rates, with global models of greater complexity, including physical and psychological symptoms as mediating factors. This is about understanding the causes with a view to establishing corrective measures and analyzing working conditions and the risks to which the worker is exposed.

For example, Goldenhar et al. (2003) proposed a model showing the relationship between job stressors and injury/near-miss outcomes. The three-part model was comprised of job stressors as the predictor variables, psychological/physical symptoms as mediators, and injuries/near-misses as final outcomes or results. The main strength of the proposed model was that it took into account the possibility of all three components. Lopez-Araujo and Segovia (2010) studied a model which analyzed the relationship, through psychological and physical malaise, between the organizational variables of stress in the workplace, safety climate and social support with regard to accidents, and incidents involving employees working in the construction industry. Finally Abbe et al. (2011) developed a model to investigate the degree of relationship between job stressors, physical and psychological symptoms, occupational incidents and accidents, and days of work lost, basing on the model proposed by Goldenhar et al. (2003).

The objective of this study was to create a model comprising the predictor variables (hygiene conditions, ergonomic conditions, and job demands) in order to determine which of them affect – and how much they affect – the mediating variables (psychological disorders and musculoskeletal disorders) and finally, occupational accidents.

To this end, it has been proposed using Bayesian networks (BNs) models that provide information of the relationship between all the studied variables. The BN model is a data mining technique that permit extracting knowledge from a database; in this case, the models have been created from the results of the VI NSWC of Spain.

The Bayesian network (BN) method is becoming increasingly popular. It has been used in several knowledge areas, such as medicine (Antal et al., 2004), ecology and natural resources management (Borsuk et al., 2004; McCann et al., 2006), geology (Rivas et al., 2007), lifecycle engineering (Zhu and Deshmukh, 2003), software engineering (Fenton et al., 2007), and reliability (Langseth and Portinale, 2007).

Bayesian networks are also being applied to other safety related research. For instance, the paper by Ren et al. (2008) aimed to contribute to offshore safety assessments by proposing a methodology to model causal relationships with a BN capable of providing graphical inter-relationships and of calculating numerical values for the likelihood of each failure event occurring. Zhou et al. (2008) proposed a BN model to establish a probabilistic relational network among causal factors, including safety climate factors and personal experience factors, which exert influences on human safety behavior. Martin et al. (2009) used BNs to analyze workplace accidents involving auxiliary equipment (ladders, scaffolding, etc.). This enabled them to identify the circumstances that have the greatest bearing on workplace accidents during these activities, such as the adoption of incorrect work postures, the duration of tasks, and a worker's inadequate knowledge of safety regulations. Others have applied BNs to road accidents; Helai et al. (2008) developed a Bayesian hierarchical binomial logistic model to identify the significant factors affecting the severity level of driver injury and vehicle damage in road accidents at signalized intersections. Ozbay and Noyan (2006) represented incident clearance patterns with formalisms based on BNs to allow traffic operators to create case-specific incident management strategies in the presence of incomplete information and De Oña et al. (2011) showed the possibility of using BNs to classify road accidents according to the severity of the injuries sustained. Finally, McCabe et al. (2008) used BNs to demonstrate that great pressure at work, high levels of interpersonal conflict, and low-quality leadership were strongly associated with work-related health outcomes and accidents.

Graphical models, us BNs models, provide a useful way of dealing with complex problems because of their capability to